The influence of landscape configuration on riverine nitrate & phosphorus dynamics

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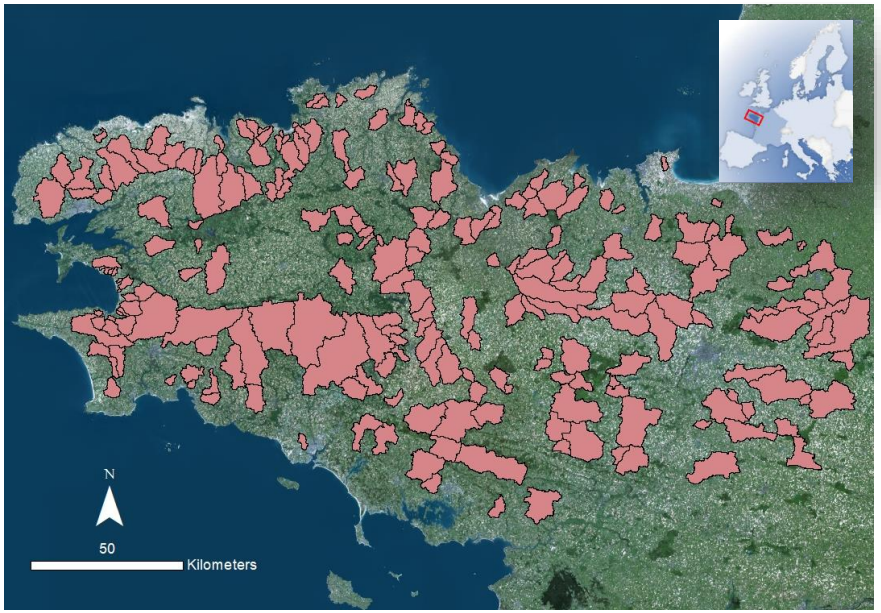
EGU General Assembly 2022

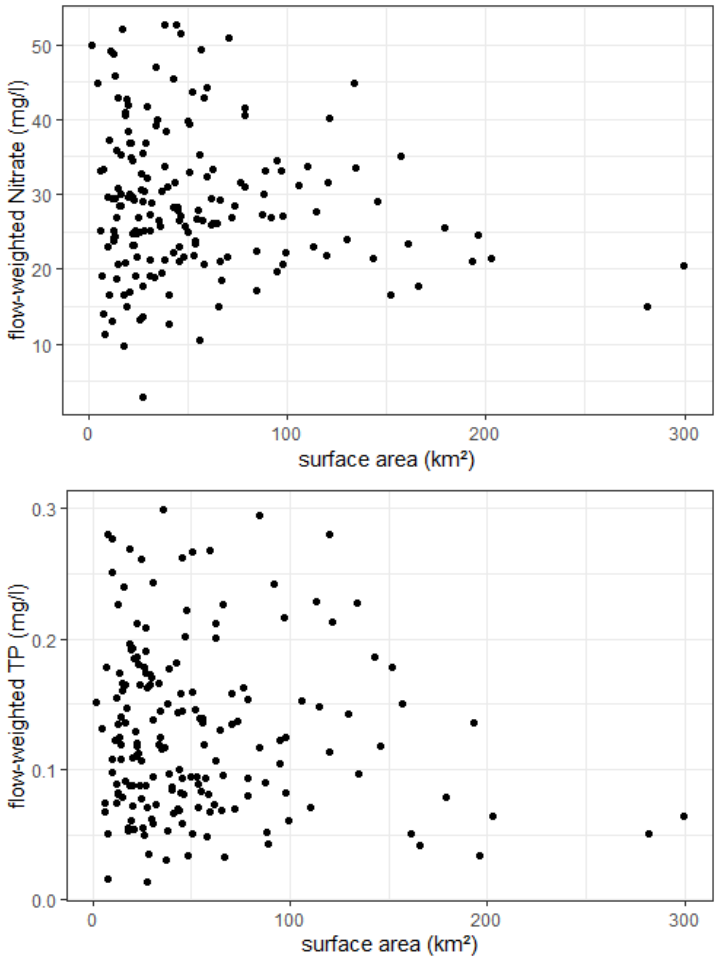
HS2.3.2 "Water quality and water age analysis to understand flow and transport processes in catchments"

Does landscape spatial configuration influence nitrate and phosphorus

1. Mean concentration?
2. Concentration dynamics?

Study area & data

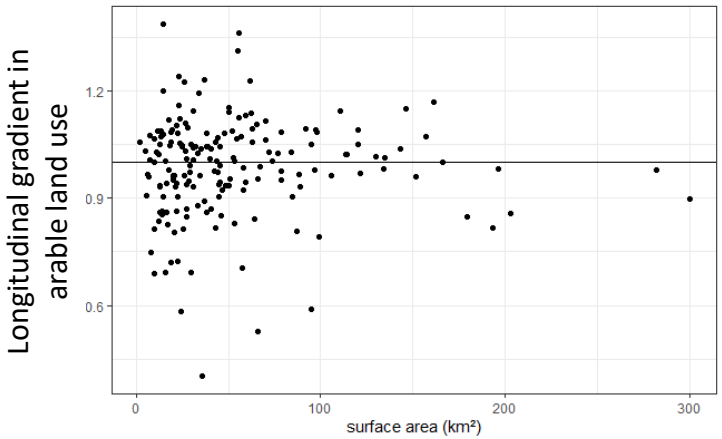




- 180 catchments (1-300km²)
- Monthly nitrate and total phosphorus data (2010-2020)
- Daily discharge measured or modelled (2010-2020)
- Variables: flow-weighted concentration, slope of log(concentration)~log(discharge), CV concentration / CV discharge

➢ **Higher variability in nitrate (and TP?) concentration among smaller catchments**

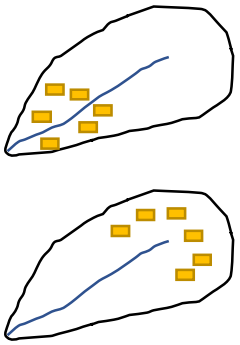
Variability in landscape configuration as a function of catchment size

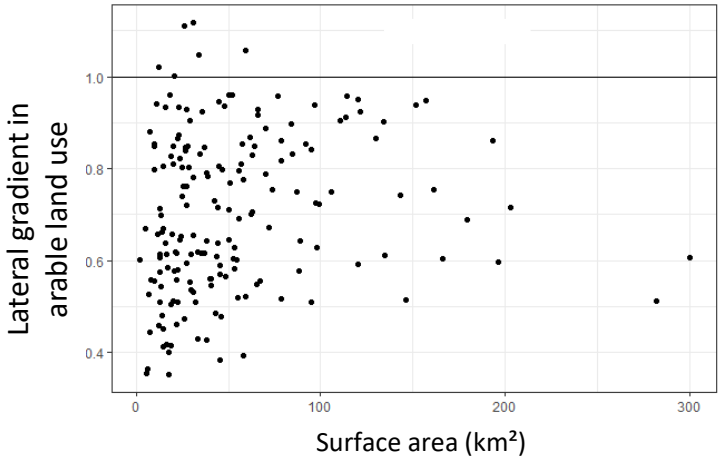


arable fields towards the downstream part of the catchment

"random" spatial organization of arable fields in the longitudinal dimension

arable fields towards the upstream part of the catchment

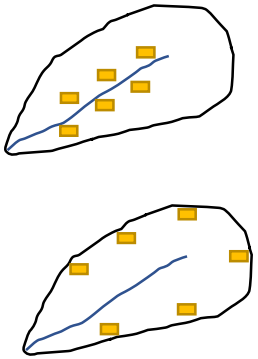




arable fields towards the downslope part of the catchment

"random" spatial organization of arable fields in the lateral dimension

arable fields towards the upslope part of the catchment



- **Arable fields preferentially in the upslope part of catchments, no preferential distribution in the longitudinal dimension**
- **Higher variability in landscape configurations in smaller catchments**

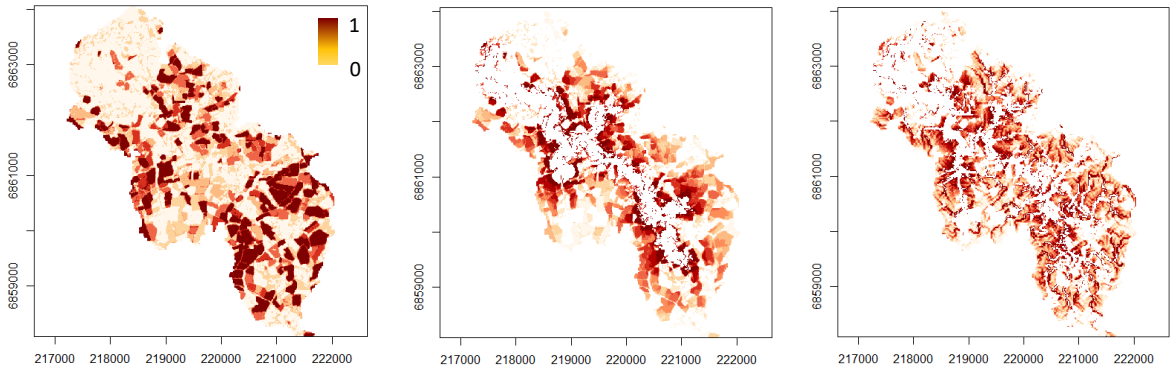
The landscape configuration index

➢ **Principle:**

Find the optimal weighting function to predict concentrations with a topography weighted % arable land use

We increase the weight of **pixels near the stream network**

We increase the weight of pixels **near the stream** and **flow accumulation zones**



LCI(0,0) = 0,40

LCI(0,1) = 0,35

LCI(1,1) = 0,37

= mean %arable (2015-2020)

➢ **Equation:**

- $$LCI = \frac{\sum_{pixel} \frac{Flowacc^a}{Distance^b} * source}{\sum_{pixel} \frac{Flowacc^a}{Distance^b}}$$

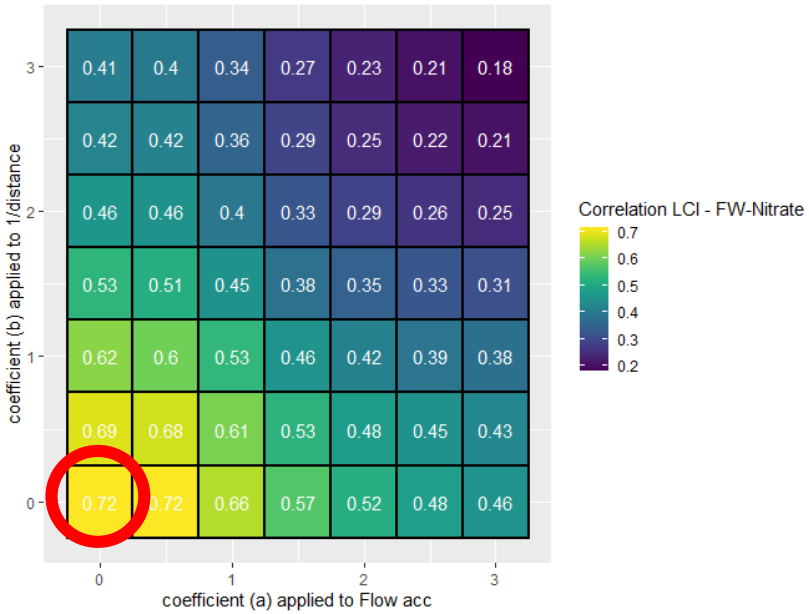
- *Flowacc = flow accumulation (multiple direction)*
- *Distance = flow distance to stream (10m)*
- *Source = 1 for arable land use and 0 otherwise (average 2015-2020)*
- *Resolution 10m*

- Vary a and b and compute the correlation between LCI(a,b) and nitrate & TP concentrations
- Landscape configuration matters if optimal (a,b) ≠ (0,0)

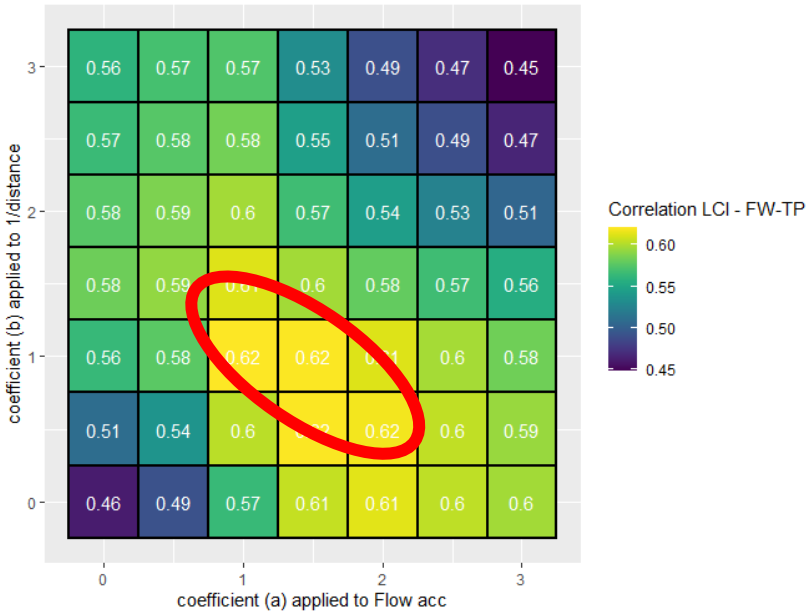
Landscape spatial configuration influences mean TP but not Nitrate

$$LCI = \frac{\sum_{pixel} \frac{Flowacc^a}{Distance^b} * source}{\sum_{pixel} \frac{Flowacc^a}{Distance^b}}$$

Nitrate



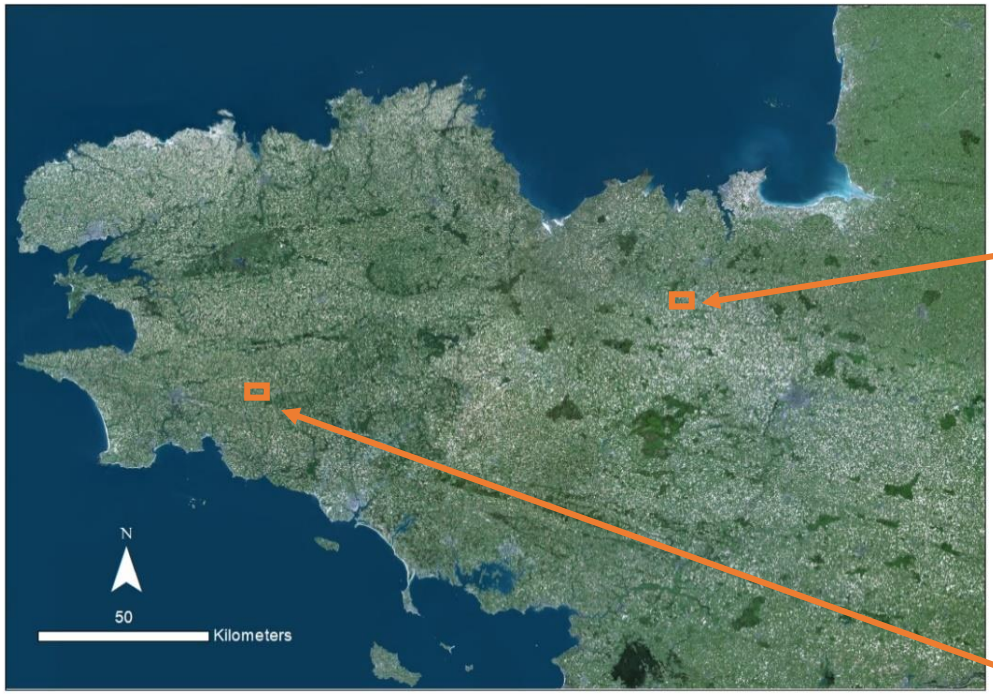
Total phosphorus



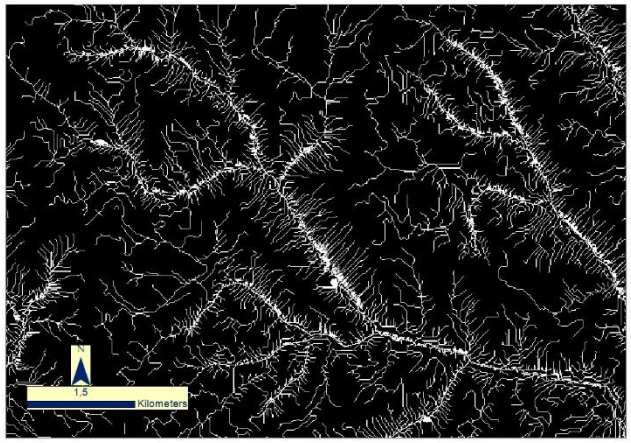
- LCI(0,0) -> landscape composition is a good predictor of Nitrate concentration, no major influence of landscape spatial configuration

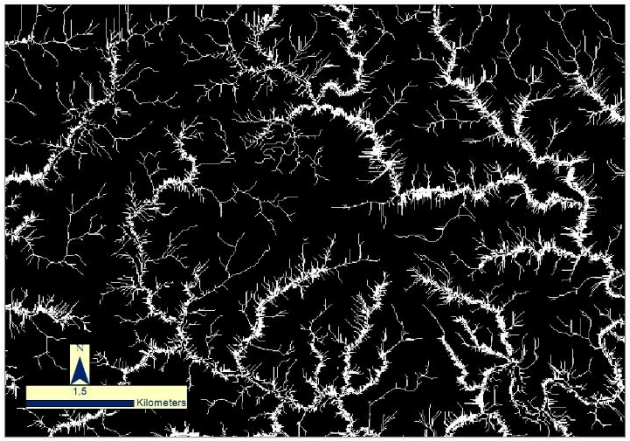
- Optimal LCI(a,b) ≠ LCI(0,0) -> consideration for landscape configuration improves prediction of TP compared to landscape composition alone

Critical source areas for total phosphorus



Areas > 90th percentile of the weighting factor used for CSA mapping





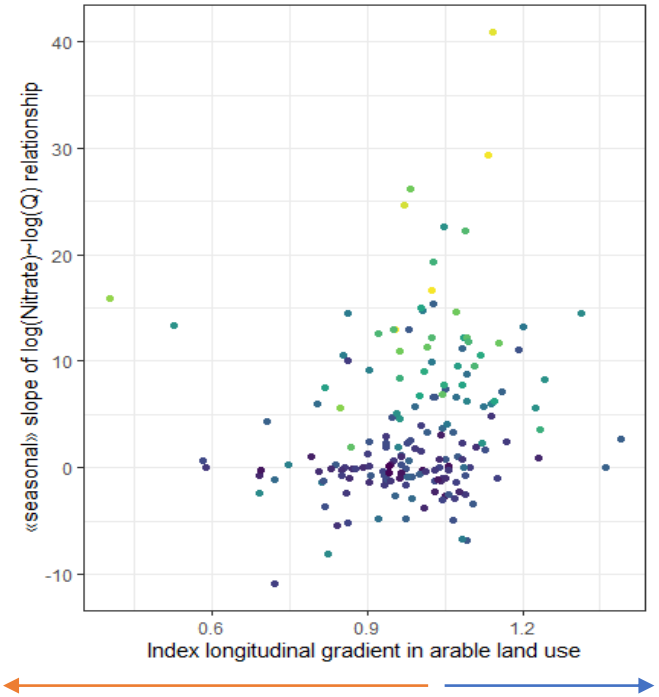
- Potential recommendation for management :
  - Relocate arable fields outside CSA
  - Increase hedgerow density within CSA

Does landscape spatial configuration influence nitrate and phosphorus

1. Mean concentration?
2. Concentration dynamics?

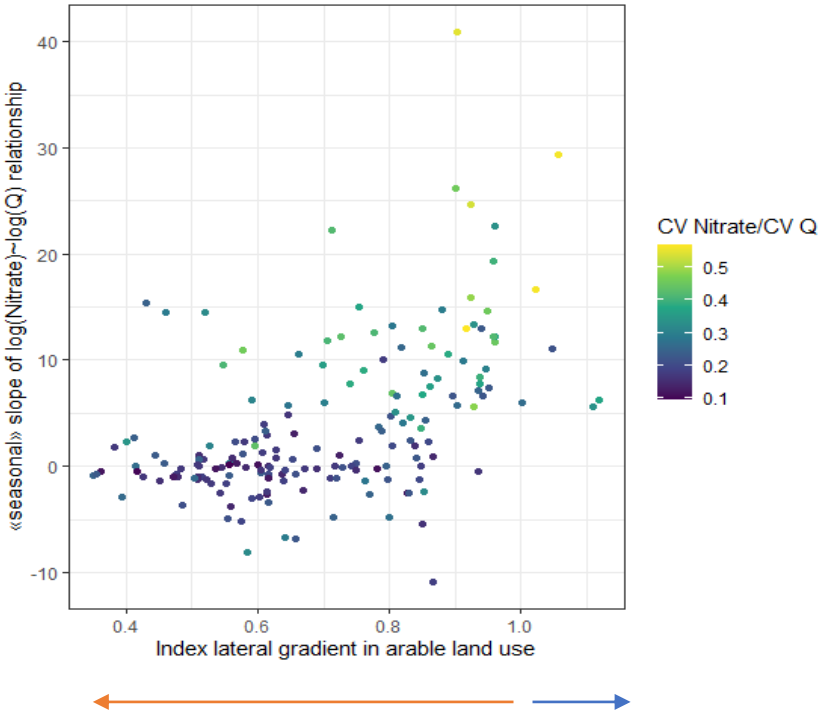
No clear influence of landscape spatial configuration on nitrate seasonal dynamics…

- *The "seasonal" concentration-discharge relationship is calculated from monthly averaged data*
- *It quantifies the seasonality of nitrate concentrations and its degree of synchrony with discharge*



arable fields towards the upstream part of the catchment

arable fields towards the downstream part of the catchment



arable fields towards the upslope part of the catchment

arable fields towards the downslope part of the catchment

No clear influence of landscape spatial configuration on nitrate seasonal dynamics…

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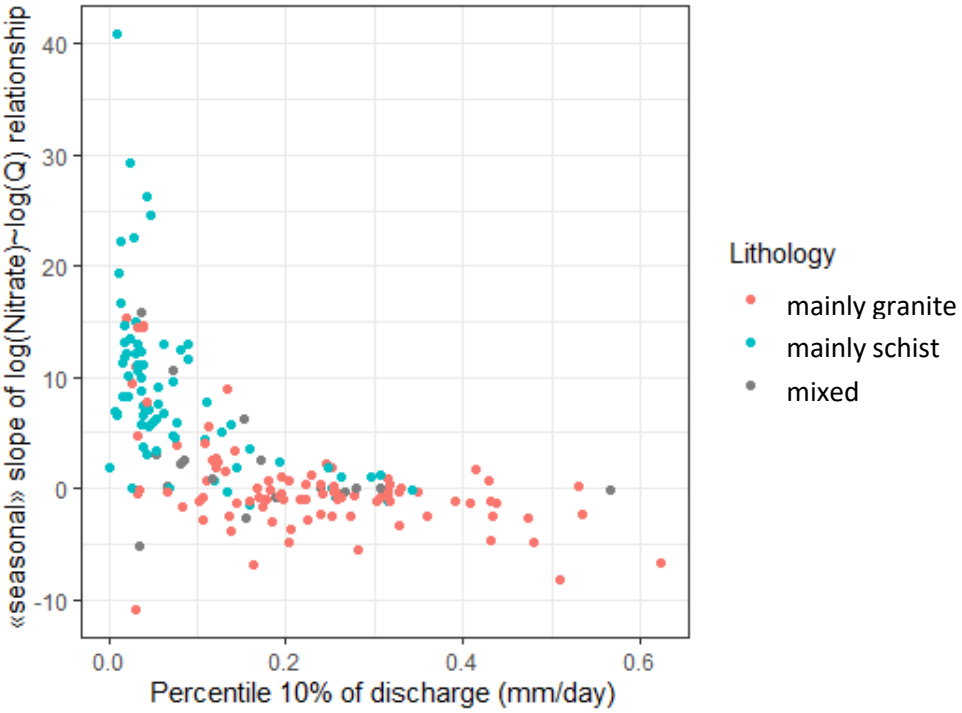
- *It quantifies the seasonality of nitrate concentrations and its degree of synchrony with discharge*



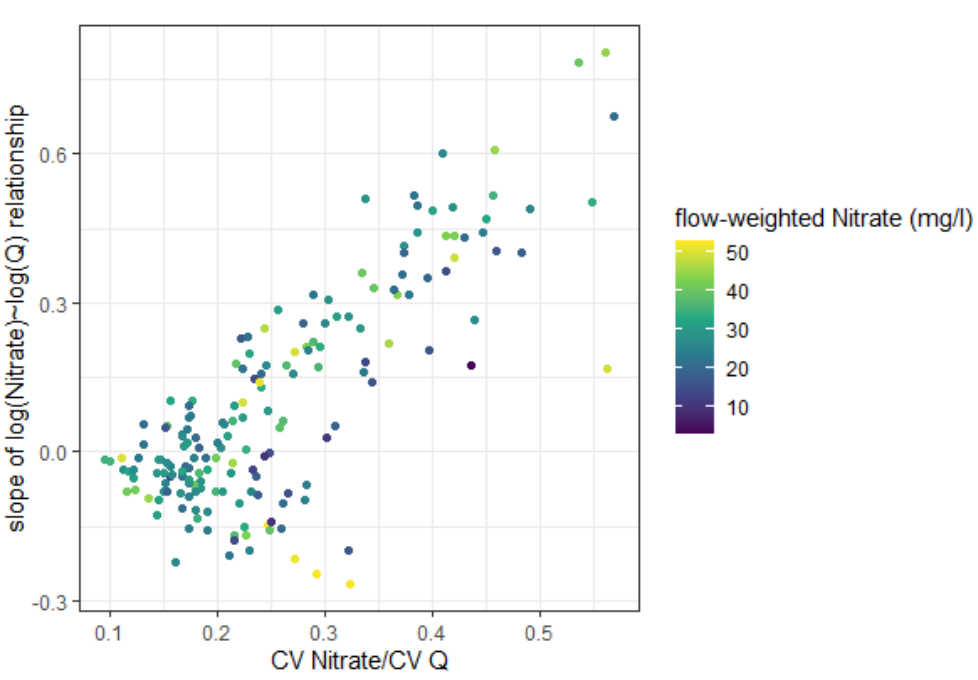
… because N seasonal pattern is predominantly controlled by the supply of water at low flow (itself determined by lithology & climate)

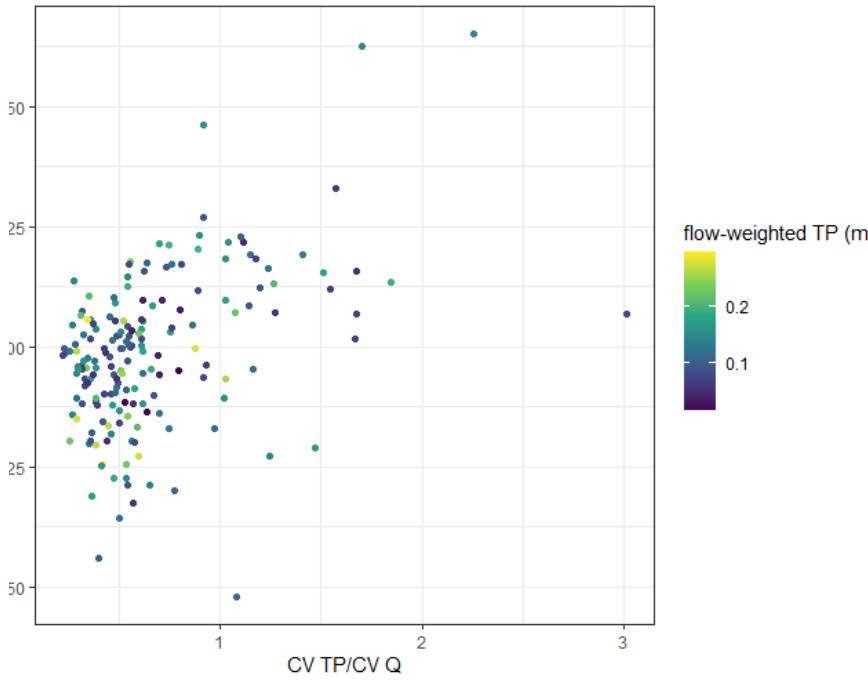
Does landscape spatial configuration influence nitrate and phosphorus

1. Mean concentration?
   - Landscape spatial configuration, as characterized with LCI, does influence total phosphorus concentration but not nitrate concentration

2. Concentration dynamics?
   - It does not appear to be a first order control

Supplement


slope of log(Nitrate)~log(Q) relationship
0.6
0.3
0.0
-0.3
0.1
0.2
0.3
0.4
0.5
CV Nitrate/CV Q
flow-weighted Nitrate (mg/l)
50
40
30
20
10


50
25
00
25
50
1
2
3
CV TP/CV Q
flow-weighted TP (m
0.2
0.1

Reference

Landscape Ecol
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RESEARCH ARTICLE

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